

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Before the Board of Patent Appeals and Interferences

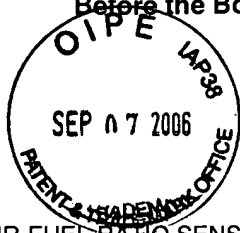
In re Patent Application of

SUGIYAMA et al

Serial No. 09/098,730

Filed: June 18, 1998

Title: MULTILAYERED AIR-FUEL RATIO SENSOR



Atty Dkt. 2635-61

C# M#

TC/A.U.: 1753

Examiner: Olsen, K.

Date: September 7, 2006

Mail Stop Appeal Brief - Patents

Commissioner for Patents

P.O. Box 1450

Alexandria, VA 22313-1450

Sir:

☐ **Correspondence Address Indication Form Attached.**

☐ **NOTICE OF APPEAL**

Applicant hereby **appeals** to the Board of Patent Appeals and Interferences

from the last decision of the Examiner twice/finally rejecting applicant's claim(s). \$500.00 (1401)/\$250.00 (2401) \$

☒ An Amended Appeal **BRIEF** is attached in the pending appeal of the above-identified application \$500.00 (1402)/\$250.00 (2402) \$ 500.00

☐ Credit for fees paid in prior appeal without decision on merits -\$ ()

☐ A reply brief is attached. (no fee)

☐ Petition is hereby made to extend the current due date so as to cover the filing date of this paper and attachment(s)
 One Month Extension \$120.00 (1251)/\$60.00 (2251)
 Two Month Extensions \$450.00 (1252)/\$225.00 (2252)
 Three Month Extensions \$1020.00 (1253)/\$510.00 (2253)
 Four Month Extensions \$1590.00 (1254)/\$795.00 (2254) \$

☐ "Small entity" statement attached.

Less Appeal Brief Fee previously paid on February 2, 2006 -\$(500.00)

TOTAL FEE ENCLOSED \$ -0-

Any future submission requiring an extension of time is hereby stated to include a petition for such time extension. The Commissioner is hereby authorized to charge any deficiency, or credit any overpayment, in the fee(s) filed, or asserted to be filed, or which should have been filed herewith (or with any paper hereafter filed in this application by this firm) to our **Account No. 14-1140**. A duplicate copy of this sheet is attached.

901 North Glebe Road, 11th Floor
 Arlington, Virginia 22203-1808
 Telephone: (703) 816-4000
 Facsimile: (703) 816-4100
 MNL:slj

NIXON & VANDERHYE P.C.

By Atty: Michelle N. Lester, Reg. No. 32,331

Signature: _____

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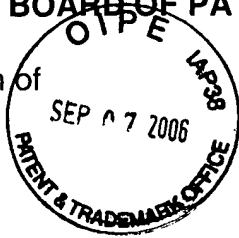
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RESPONSE TO NOTIFICATION OF NON-COMPLIANT APPEAL BRIEF

Sir:

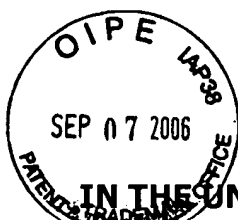
Responsive to the Notification of Non-Compliant Appeal Brief dated September 5, 2006 an amended Appeal Brief is attached. The Notification of Non-Compliant Appeal Brief alleged that the Brief did not contain a concise explanation of the subject matter defined in each of the independent claims involved in the Appeal. This is not correct. The Brief on Appeal filed February 2, 2006 included a concise explanation of the subject matter defined in each of independent claims 1, 18, 33 and 39, and referred to the specification by page and line number and to the drawings by reference characters. The concise explanations did not refer to the respective independent claims by claim number, but this is not a requirement of 37 CFR 41.37(c)(1)(v). In view of the Examiner's objection to the Brief and in the interest of advancing this appeal, however, the herewith amended Appeal Brief now includes references to the independent claims by claim number. An early and favorable decision on Brief is solicited.

Respectfully submitted,
NIXON & VANDERHYE P.C.

By: 

Michelle N. Lester
Reg. No. 32,331

MNL:sj
901 North Glebe Road, 11th Floor
Arlington, VA 22203-1808
Telephone: (703) 816-4000
Facsimile: (703) 816-4100



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AMENDED APPEAL BRIEF

Sir:

Applicant submits herewith their Amended Brief on Appeal pursuant to 37 CFR
§41.37.

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(I) REAL PARTY IN INTEREST

The real party in interest is the assignee, DENSO CORPORATION, a corporation of Japan.

(II) RELATED APPEALS AND INTERFERENCES

A Brief on Appeal was previously filed in the subject application on October 23, 2001. The Appeal was assigned Appeal No. 2002-1284 and a Decision on said Brief was mailed July 8, 2003. A copy of said Decision is included in Appendix X hereto. On information and belief there are no other prior or pending appeals, interferences, or judicial proceedings (past or present), known to appellant, the appellant's legal representative, or assignee, which may be related to, directly affect or be directly affected by or have a bearing on the Board's decision in this appeal.

(III) STATUS OF CLAIMS

Claims 1, 2, 4, 6, 7, 10, 11, 18-22 and 24-48 remain pending. Claims 3, 5, 8-9, 12-17 and 23 have been canceled. Claims 1, 2, 4, 6, 7, 10, 11, 18-22 and 24-48 are rejected. The rejection of claims 1, 2, 4, 6, 7, 10, 11, 18-22 and 24-48 is being appealed. A current listing of claims is presented in the Claims Appendix of this Brief.

(IV) STATUS OF AMENDMENTS

No amendment was filed subsequent to the final rejection of August 9, 2005.

(V) SUMMARY OF CLAIMED SUBJECT MATTER

The invention relates to multilayered air-fuel ratio sensors of the sort which are used to control the operation of an internal combustion engine. In such air-fuel ratio sensors, a series of substrate layers, including at least one solid electrolytic substrate layer and at least one insulating substrate layer, are laminated together. Various ones of the layers have cavities formed in them. A reference gas (e.g., air) is introduced into one such cavity, and gas being measured (e.g., exhaust gas) is introduced into another chamber. Appropriate electrodes are formed on opposite surfaces of the electrolytic substrate layer, and by measuring one or more electrical parameters such as current flow or voltage across the electrolytic substrate layer between the electrodes, various parameters of interest (air-fuel ratio, carbon monoxide concentration, nitrogen oxide concentration, etc.) can be ascertained, as is known in the art.

As is also known in the art, in order for such air-fuel ratio sensors to function properly, the sensing element needs to be at a predetermined, elevated active temperature. Therefore, such air-fuel ratio sensors typically also have a heater to heat the sensor element to the active temperature. Heating the sensor can cause thermal shock and/or thermally induced stress, which can cause cracks to form in the sensor. Such cracks can cause the sensor to break (as a result of vibration to which it is subjected) or otherwise fail. The present invention overcomes such drawbacks in the prior art.

According to the present invention, an air-fuel ratio sensor includes, in addition to at least one solid electrolytic substrate layer and at least one insulating substrate layer, a boundary layer that is interposed between the solid electrolytic substrate layer and the insulating layer. The boundary layer has an average sintered particle size that is larger than the average sintered particle size of the electrolytic substrate layer and that is larger than the average sintered particle size of the insulating substrate layer. As illustrated in Figures 5 and 6, of the application, providing such a boundary layer

(termed a "heterogeneous layer" in those Figures) significantly increases the sensor's bending strength (which increases the sensor's resistance to breaking) and the sensor's spalling strength (which increases the sensor's ability to withstand thermal shock).

Thus, and more specifically, as defined in claim 1, the invention provides a multilayered air-fuel ratio sensor having a plurality of stacked layers comprising: a plurality of substrate layers comprising at least one solid electrolytic substrate layer 11-13,31 and at least one insulating substrate layer 22,24,42; and a boundary layer 10 interposed immediately between said solid electrolytic substrate layer and said insulating substrate layer without any other intervening layer (page 11, lines 17-18; page 12, lines 18-23; page 14, line 25- page 15, line 1; Figs. 7, 8, 11); wherein each of said solid electrolytic substrate layer, said insulating substrate layer, and said boundary layer is obtained by sintering (page 9, lines 26-29) original particles of a source material (page 8, lines 2-5; page 9, lines 10-13) so as to change the original particles to sintered particles, and an average size of the sintered particles of said boundary layer is adjusted to be larger than an average size of the sintered particles of each of said solid electrolytic substrate layer and said insulating substrate layer (page 6, lines 20-25; page 9, lines 23-29; page 13, lines 13-16).

The invention also provides, as defined in claim 18, a multilayered air-fuel ratio sensor having a plurality of stacked layers comprising: a plurality of substrate layers comprising at least one solid electrolytic substrate layer 11-13,31 and at least one insulating substrate layer 22,24,42; and a boundary layer 10 interposed immediately between said solid electrolytic substrate layer and said insulating substrate layer without any other intervening layer (page 11, lines 17-18; page 12, lines 18-23; page 14, lines 26-page 15, line 1; Figs. 7, 8, 11); wherein each of said solid electrolyte substrate layer, said insulating substrate layer, and said boundary layer is obtained by sintering (page 9, lines 26-29) original particles of a source material (page 8, lines 2-5; page 9, lines 10-13) so as to change the original particles to sintered particles, and an

average size of the sintered particles of said boundary layer is adjusted to be larger than an average size of the sintered particles of each of said solid electrolytic substrate layer and said insulating substrate layer and wherein the composition of said boundary layer is different from the composition of said solid electrolytic substrate layer (page 6, lines 20-25; page 9, lines 23-29; page 13, lines 13-16).

The invention also provides, as defined in claim 33, a multilayered air-fuel ratio sensor having a plurality of stacked layers comprising: a plurality of substrate layers comprising one solid electrolytic substrate layer 11,13 serving as a ceiling or a bottom of a sample gas chamber 120 into which a sample gas is introduced and another solid electrolytic substrate layer 12 defining side walls of said sample gas chamber; and a boundary layer 10 interposed immediately between said one solid electrolytic substrate layer 11,13 and said another solid electrolytic substrate layer without any other intervening layer (page 11, lines 17-18; Fig. 2); wherein each of said one solid electrolytic substrate layer, said another solid electrolytic substrate layer, and said boundary layer is obtained by sintering (page 9, lines 26-29) original particles of a source material (page 8, lines 2-5; page 9, lines 10-13) so as to change the original particles to sintered particles, and an average size of the sintered particles of said boundary layer is adjusted to be larger than an average size of the sintered particles of each of said solid electrolytic substrate layers (page 6, lines 20-25; page 9, lines 23-29; page 13, lines 13-16).

The invention also provides, as defined in claim 39, a multilayered air-fuel ratio sensor having a plurality of stacked layers comprising: a plurality of substrate layers comprising one solid electrolytic substrate layer 11,13 serving as a ceiling or a bottom of a sample gas chamber 120 into which a sample gas is introduced and another solid electrolytic substrate layer 12 defining side walls of said sample gas chamber; and a boundary layer 10 interposed immediately between said one solid electrolytic substrate layer 11,13 and said another solid electrolytic substrate layer without any other

intervening layer (page 11, lines 17-18; Fig. 2); wherein each of said one solid electrolytic substrate layer, said another solid electrolytic substrate layer, and said boundary layer is obtained by sintering (page 9, lines 26-29) original particles of a source material (page 8, lines 2-5; page 9, lines 10-13) so as to change the original particles to sintered particles, and an average size of the sintered particles of said boundary layer is adjusted to be larger than an average particle size of the sintered particles of said solid electrolytic substrate layers, and wherein the composition of said boundary layer is different from the composition of each of said solid electrolytic substrate layers (page 6, lines 20-25; page 9, lines 23-29; page 13, lines 13-16).

In an example embodiment, as defined in claims 2 and 19, the multilayered air-fuel ratio sensor boundary layer has a porosity larger than that of said substrate layers (page 13, lines 10-12). According to a further feature of an example embodiment of the invention, as defined in claims 7 and 22, the substrate layers comprise a plurality of solid electrolytic substrate layers, and further comprising a plurality of additional boundary layers, respectively interposed immediately between two consecutive solid electrolytic substrate layers without any other intervening layer (Fig. 2-3, 7-8). Further, according to an example embodiment of the invention, as defined in claims 45-48, an average size of the original particles of said boundary layer is smaller than an average size of the original particles of each of said substrate layers (compare page 8, lines 2-5; page 9, lines 10-13; and page 6, lines 20-25).

wherein each of said one solid electrolytic substrate layer, said another solid electrolytic substrate layer, and said boundary layer is obtained by sintering original particles of a source material so as to change the original particles to sintered particles, and an average size of the sintered particles of said boundary layer is adjusted to be larger than an average particle size of the sintered particles of said solid electrolytic substrate layers, and wherein the composition of said boundary layer is different from the composition of each of said solid electrolytic substrate layers.

40. (previously presented) The multilayered air-fuel ratio sensor in accordance with claim 39, wherein said boundary layer is made of α -alumina with an average sintered particle size of 3 to 4 μm .

41. (previously presented) The multilayered air-fuel ratio sensor in accordance with claim 39, wherein

said solid electrolytic substrate layers are made of partially-stabilized zirconia with an average sintered particle size of 2 to 3 μm , and

said boundary layer is made of α -alumina with an average sintered particle size of 3 to 4 μm .

42. (previously presented) The multilayered air-fuel ratio sensor in accordance with claim 41, wherein

an alumina green sheet for said boundary layer has an average particle diameter smaller than that of a zirconic green sheet for said solid electrolytic substrate layers.

43. (previously presented) The multilayered air-fuel ratio sensor in accordance with claim 39, wherein

said solid electrolytic substrate layers are made of partially-stabilized zirconia and said boundary layer is made of alumina, and

(VI) GROUND OF REJECTION TO BE REVIEWED ON APPEAL

Claims 1, 2, 4, 6, 7, 10, 11, 18-22, 26, 29-33, 36-39 and 42-48 stand rejected under 35 USC §103(a) as being unpatentable over Mase et al. '456 in view of Suzuki et al. At the outset it is noted that claim 37 and 43 have been separately rejected below with further reference to Mase '126. It is therefore understood that they were not intended to be listed in the rejection based on Mase '456 and Suzuki.

Claims 24, 27, 34 and 40 stand rejected under 35 USC §103(a) as being unpatentable over Mase et al. '456 in view of Suzuki et al. and Sugino and Tatumoto et al.

Claims 25, 28, 35 and 41 stand rejected under 35 USC §103(a) as being unpatentable over Mase et al. '456 in view of Suzuki et al. and Watanabe et al. or Ikezawa et al.

Claims 37 and 43 stand rejected under 35 USC §103(a) as being unpatentable over Mase et al. '456 in view of Suzuki et al. and further in view of Mase et al. '126.

(VII) ARGUMENT

A. Claims 1, 2, 4, 6, 7, 10, 11, 18-22, 26, 29-33, 36-39 [sic 36,38-39] and 42-48 [sic 42,44-48] are patentable as not having been obvious from Mase et al. '456 in view of Suzuki et al.

As described in the "Background of the Invention" section of this application, a conventional multi-layered air-fuel ratio sensor is comprised of a solid electrolytic substrate layer 91, an insulating spacer 92, a solid electrolytic substrate layer 93, and a shielding plate 94. The conventional insulating spacer 92 is formed from alumina whereas the substrate layers and shielding plate are conventionally formed from zirconia. A sample chamber is defined by the insulating spacer and the shielding plate is configured to define a reference chamber in the example of Figures 13-14. In general, the air-fuel ratio sensor functions properly only when it is at a temperature exceeding a predetermined active temperature. Thus, a heater is typically provided to assure accurate operation of the air-fuel ratio sensor. To meet tough emission controls, the sensor must have an excellent warm-up ability. For example, the sensor must be warmed up for operation within a period of about 5 seconds. This subjects the multi-layered air-fuel ratio sensor to severe thermal shocks. To reduce these thermal shocks, one might reduce the overall thickness of the air-fuel ratio sensor to reduce the heat-up time. However, this would correspondingly reduce the mechanical strength of the sensor. Since the sensor is usually assembled with the heater and installed in an exhaust passage of an internal combustion engine, the sensor is exposed to various external forces and vibrations. If the mechanical strength is decreased by reducing the thickness, to reduce warm-up time, it may be damaged by such external forces.

Thus, it was an object of the invention to provide a multi-layered air-fuel ratio sensor having excellent warm-up ability and which is capable of effectively preventing cracks caused due to thermal shocks. This object of the invention was achieved by providing a heterogeneous boundary layer interposed between the substrate layers of

the sensor. The heterogeneous boundary layer absorbs thermal shocks or other stresses that act on the substrate layers and stops the growth of cracks. The heterogeneous boundary layer has a sintering particle diameter larger than that of adjacent substrate layers. In an example embodiment, the heterogeneous boundary layer also has a porosity rate greater than that of the neighboring substrate layers.

Claims 1 and 18 recite that "each of said solid electrolytic substrate layer, said insulating substrate layer and said boundary layer is obtained by sintering original particles of a source material so as to change the original particles to sintered particles" and that "an average size of the sintered particles of the boundary layer is adjusted to be larger than an average size of the sintered particles of each of said solid electrolytic substrate layer and said insulating substrate layer". Similarly, claims 33 and 39 recite that "each of said solid electrolytic substrate layer, said another solid electrolytic substrate layer, and said boundary layer is obtained by sintering original particles of a source material so as to change the original particles to sintered particles" and that "an average size of the sintered particles of said boundary layer is adjusted to be larger than an average size of the sintered particles of each of said solid electrolytic substrate layers". The limitations of these claims are supported by the entire original disclosure including in particular page 6, lines 20-25, and page 9, lines 23-29.

Mase '456 discloses an electrochemical device such as an oxygen sensor comprising a plurality of solid electrolyte bodies and at least one electrical insulation layer (see Abstract). More particularly, an electrical insulation layer 54 is disposed between an inner gastight ceramic layer 50 and a solid electrolyte body 28 (see column 4, lines 38-40, and column 8, lines 4-7), and an electrical insulation layer 34 is disposed between a zirconia solid electrolyte member 8 and the solid electrolyte body 28 (see Fig. 2). The insulation layer 54 is formed of the same material as that used for the insulation layers 20, 26 and 34 (see column 8, lines 10-14), and the insulation layers 20, 26 and 34 are ceramic layers comprising alumina or spinal (see column 6, lines 50-

54). The solid electrolyte body 28 is made of zirconia ceramics or the like (see column 5, lines 27-28). As noted by the Examiner, Mase discloses insulation layers 20, 26 and 34 "are made porous" at column 6, line 62. Since insulation layer 54 is formed of the same material used for insulation layers 20, 26 and 34, the Examiner has assumed that layer 54 is also porous although this is not explicitly stated in Mase. The insulation layers are characterized as porous for minimizing stress due to a difference in coefficient of thermal expansion between those insulation layers and the solid electrolyte materials 8, 10, 28. More specifically, the porosity is characterized as effective for preventing flake off of the layers and the solid electrolyte members. However, it is noteworthy that nothing is said regarding bending strength. Moreover, and importantly, Mase '456 does not compare or contrast the "porosity" of layer 54 (or layers 20, 26 and 34) with any adjacent layer.

In contrast, the inventors of the present invention have noticed that the breaking strength of the sensor can be improved when sizes of sintered particles among the boundary layer, the solid electrolytic substrate layer and the insulating substrate layer satisfy a particular relationship (see page 11, lines 6-7 of the present specification). Based on this discovery, source materials of the solid electrolytic substrate layer, the insulating substrate layer and the boundary layer are sintered to change the original particles thereof to sintered particles, and an average size of the sintered particles of the boundary layer is adjusted to be larger than that of each of the solid electrolytic substrate layer and the insulating substrate layer. Mase '456 does not teach or suggest the foregoing unique and advantageous feature of the invention.

The Examiner seeks to overcome the deficiencies of Mase '456 with respect to the invention claimed by relying upon the secondary reference to Suzuki.

Suzuki discloses an oxygen concentration detector. Suzuki's detector has an oxygen concentration sensor 1, a first electrode 2, a first coating 4 and a second

coating 4' in that order. Fine grains of Al_2O_3 having an average grain size of approximately 10μ are deposited on the surface of the first electrode 2 by plasma injection-welding to form the first coating 4 having a number of pores. Coarse grains of Al_2O_3 having an average grain size of approximately 40μ are deposited on the surface of the first coating 4 to form a second coating 4' having a number of coarse pores (see Fig. 2, and column 2, lines 38-47).

Suzuki discloses nothing regarding sintering particles of a source material so as to change the original particles to sintered particles nor adjusting the sintered particles of a particular layer to be larger than the sintered particles of other layers. Indeed, because of the plasma injection-welding, an average grain size of injected grains of Al_2O_3 will be substantially the same as the course grain not yet injected. Thus, there is no teaching or suggestion in Suzuki of sintering particles so as to change the particles to sintered particles and adjusting particles to be larger for a particular layer.

If the teachings concerning the second coating 4' of Suzuki are applied to the formation of the insulation layer 54 of Mase, as suggested by the Examiner, the insulation layer 54 will be formed by depositing coarse grains of Al_2O_3 having an average grain size of approximately $40\mu\text{m}$ on the surface of solid electrolyte body 28 by plasma injection-welding. However, because the grain size of injected grains is the same as the coarse grains (source material) not yet injected, Suzuki does not teach or suggest sintering original particles of a source material so as to change the original particles to sintered particles and adjusting an average size of the sintered particles so that the sintered particles of the boundary layer are larger than the sintered particles of the solid electrolyte substrate layer. Further in this regard, it is noted that neither Mase nor Suzuki teach or suggest an object of improving the breaking strength of the sensor, nor do they teach or suggest to the skilled artisan how this might be achieved.

According to the Examiner's interpretation of Mase, Mase already discloses that layer 54 is a porous layer. There is no teaching or suggestion in Mase that this layer must be more or less porous than the adjacent layers. Suzuki teaches one method by which coarser (larger) pores may be provided, by plasma-injection welding grains of Al_2O_3 , but Suzuki does not motivate the skilled artisan to modify Mase so as to provide insulation layer 54 more porous than adjacent layers and certainly does not teach or suggest forming the insulation layer 54 by sintering source material particles and adjusting the grain size relative to that of adjacent layers, as recited in applicant's independent claims.

The Examiner has asserted with respect to claims 45-48 that the relative size of particles prior to sintering constitutes a process for making the device. Applicant respectfully disagrees. The independent claims specifically detail the sintering of source materials and the adjustment of size to provide the product. Thus, the formation steps define and characterize the formed product. It is only proper for the Examiner to "ignore" process steps where the final product is indistinguishable on the basis of the method by which it is formed, which is not the case here. Therefore, the Examiner's disregard for the limitations of claims 45-48 is submitted to be without merit. Indeed, the product claim is not identical to the combination of Mase and Suzuki because the product formed by the Suzuki process, if incorporated in Mase, would not correspond to that formed in the manner recited in applicant's claims.

For all of the reasons advanced above, reversal of the rejection of claims 1, 18, 33 and 39 and the claims dependent directly or indirectly therefrom is respectfully requested.

B. Claims 24, 27, 34 and 40 are patentable as not having been obvious from Mase '456 in view of Suzuki et al and Sugino et al and Tatumoto et al

These claims are submitted to be patentable over Mase and Suzuki for the reasons advanced above. The Examiners further citation to Sugino and Tatumoto does not overcome the deficiencies of the primary combination noted above. It is therefore respectfully submitted that these claims are also patentable over the prior art of record.

It is further respectfully noted that according to the Examiner's combination of Mase and Suzuki, coarse grains having a grain size of 40 μ m are deposited. Although the Examiner has found a reference, Sugino, disclosing an alumina layer comprising alpha alumina and another reference, Tatumoto, disclosing alumina particles with a size of 2.3 microns. This does not *ipso facto* means that it would be "obvious" to modify the Mase/Suzuki combination to use alpha alumina with a particle size of 3 microns.

Section 103 does not allow the Examiner to engage in picking and choosing from the prior art only to the extent that it will support a holding of obviousness, while excluding parts of the prior art essential to the full appreciation of what the prior art suggests to one of ordinary skill in the art. In re Wesslau, 147 USPQ 391 (CCPA 1975).

Further note in this regard that Tatumoto describes an alumina starting material including 2.3 μ m. Thus, Tatumoto's disclosure does not relate to an average sintered particle diameter nor does it correspond to the recited range of 3 to 4 μ m. Moreover, the alumina material that Tatumoto's disclosure refers to is the layer 1, which is not a layer provided between substrate layers but rather is formed on the surface of the support body. Clearly the Examiner has taken isolated teachings of Tatumoto out of context in an attempt to reconstruct the invention from the applied art.

With regard to Sugino, the Examiner has cited column 13, line 61. As understood from the reference to trap layer 1 and Figures 2 and 3 thereof, layer 1 is disclosed as the outermost surface layer of the Sugino assembly and does not provide a teaching directed to a boundary layer interposed between substrate layers as specifically required by applicant's claims. Thus, the fact that Sugino discloses alpha

alumina does not obviously lead the skilled artisan to conclude that alpha alumina would be a suitable material in the Mase/Suzuki combination. Thus, once again, the Examiner has taken an isolated teaching of the prior art and summarily concluded, without a proper 103 analysis, that the claimed invention would have been obvious therefrom.

C. Claims 25, 28, 35 and 41 are patentable as not having been obvious from Mase et al in view of Suzuki et al and Wakanabe et al or Ikezawa et al.

These claims are submitted to be patentable over Mase and Suzuki for the reasons advanced above. The Examiner's further reliance on Wakanabe and Ikezawa does not overcome the deficiencies of the primary combination noted above. It is therefore respectfully submitted that these claims should be allowable as well.

D. Claims 37 and 43 are patentable as not having been obvious from Mase '456 in view of Suzuki et al and further in view of Mase '126.

These claims are submitted to be patentable over Mase et al. and Suzuki for the reasons advanced above.

With regard to the Examiner's further reliance on Mase '126, it is respectfully submitted that the Examiner is adopting an isolated teaching of Mase '126 out of context to the primary combination. In this regard, Mase '456 expressly teaches that his insulating substrates 20, 26, 34 and 54 are made porous to minimize stress due to a difference in coefficient of thermal expansion between the insulation layer and the solid electrolyte material. Clearly, then, Mase '456 discloses that the reason for those layers being porous is because of the difference in coefficient of thermal expansion. If there were no difference in coefficient of thermal expansion, then there would be no reason for Mase '456 to make those layers porous. Thus, the Examiner's suggestion that it would be "obvious" for the layers of Mase '456 to have substantially the same thermal

expansion coefficient is illogical because it is completely contrary to the Mase '456 disclosure. The Examiner's suggestion that making the thermal expansion coefficient substantially the same would be to prevent warping is also without basis in the applied art. Mase '456's concerns relate to flaking off of layers, not warping, and this is accommodated by providing insulation layers that are porous. Again, there is no disclosure that they are more or less porous than adjacent layers, but it is quite clear from Mase '456 that there is a difference in thermal expansion coefficient, so that the Examiner's proffered prior art combination is motivated solely by hindsight knowledge of the invention and is not a combination that one skilled in the art would obviously make without the benefit of applicant's disclosure.

CONCLUSION

For all the reasons advanced above, reversal of the Examiner's Rejection and allowance of all pending claims is solicited.

Respectfully submitted,

NIXON & VANDERHYE P.C.

By: 

Michelle N. Lester
Reg. No. 32,331

MNL:slj
901 North Glebe Road, 11th Floor
Arlington, VA 22203-1808
Telephone: (703) 816-4000
Facsimile: (703) 816-4100

(VIII) CLAIMS APPENDIX

1. (previously presented) A multilayered air-fuel ratio sensor having a plurality of stacked layers comprising:

a plurality of substrate layers comprising at least one solid electrolytic substrate layer and at least one insulating substrate layer; and

a boundary layer interposed immediately between said solid electrolytic substrate layer and said insulating substrate layer without any other intervening layer;

wherein each of said solid electrolytic substrate layer, said insulating substrate layer, and said boundary layer is obtained by sintering original particles of a source material so as to change the original particles to sintered particles, and an average size of the sintered particles of said boundary layer is adjusted to be larger than an average size of the sintered particles of each of said solid electrolytic substrate layer and said insulating substrate layer.

2. (previously presented) The multilayered air-fuel ratio sensor according to claim 1, wherein said boundary layer has a porosity larger than that of said substrate layers.

Claim 3. (canceled)

4. (previously presented) The multilayered air-fuel ratio sensor according to claim 1, wherein said boundary layer comprises a component selected from the group consisting of alumina, spinel, and steatite.

Claim 5. (canceled)

6. (previously presented) The multilayered air-fuel ratio sensor according to claim 1, wherein said boundary layer has a thickness in a range of 10 to 100 μm .

7. (previously presented) The multilayered air-fuel ratio sensor according to claim 1, wherein said substrate layers comprise a plurality of solid electrolytic substrate layers, and further comprising a plurality of additional boundary layers, respectively interposed immediately between two consecutive solid electrolytic substrate layers without any other intervening layer.

Claims 8-9. (canceled)

10. (previously presented) The multilayered air-fuel ratio sensor according to claim 1, wherein the composition of said boundary layer is different from the composition of said solid electrolytic substrate layer.

11. (previously presented) The multilayered air-fuel ratio sensor according to claim 10, wherein the composition of said boundary layer is different from the composition of said insulating substrate layer.

Claims 12-17. (canceled)

18. (previously presented) A multilayered air-fuel ratio sensor having a plurality of stacked layers comprising:

a plurality of substrate layers comprising at least one solid electrolytic substrate layer and at least one insulating substrate layer; and

a boundary layer interposed immediately between said solid electrolytic substrate layer and said insulating substrate layer without any other intervening layer;

wherein each of said solid electrolyte substrate layer, said insulating substrate layer, and said boundary layer is obtained by sintering original particles of a source material so as to change the original particles to sintered particles, and an average size

of the sintered particles of said boundary layer is adjusted to be larger than an average size of the sintered particles of each of said solid electrolytic substrate layer and said insulating substrate layer and wherein the composition of said boundary layer is different from the composition of said solid electrolytic substrate layer.

19. (previously presented) The multilayered air-fuel ratio sensor according to claim 18, wherein said boundary layer has a porosity that is larger than that of said substrate layers.

20. (previously presented) The multilayered air-fuel ratio sensor according to claim 18, wherein said boundary layer comprises a component selected from the group consisting of alumina, spinel, and steatite.

21. (previously presented) The multilayered air-fuel ratio sensor according to claim 18, wherein said boundary layer has a thickness that is in the range of 10 to 100 μ m.

22. (previously presented) The multilayered air-fuel ratio sensor according to claim 18, wherein said substrate layers comprise a plurality of solid electrolytic substrate layers, and further comprising a plurality of additional boundary layers, respectively interposed immediately between two consecutive solid electrolytic substrate layers without any other intervening layer.

Claim 23. (canceled)

24. (previously presented) The multilayered air-fuel ratio sensor according to claim 4, wherein said boundary layer is made primarily from α -alumina with an average sintering particle diameter of 3 to 4 μ m.

25. (previously presented) The multilayered air-fuel ratio sensor according to claim 4, wherein said at least one solid electrolytic substrate layer is made of yttria partially-stabilized zirconia with an average sintered particle diameter of 2 to 3 μm .

26. (previously presented) The multilayered air-fuel ratio sensor according to claim 4, wherein said insulating substrate layer is formed from a component selected from the group consisting of alumina, spinel and steatite.

27. (previously presented) The multilayered air-fuel ratio sensor according to claim 20, wherein said boundary layer is made primarily from α -alumina with an average sintered particle diameter of 3 to 4 μm .

28. (previously presented) The multilayered air-fuel ratio sensor according to claim 20, wherein said at least one solid electrolytic substrate layer is made of yttria partially-stabilized zirconia with an average sintered particle diameter of 2 to 3 μm .

29. (previously presented) The multilayered air-fuel ratio sensor according to claim 20, wherein said insulating substrate layer is formed from a component selected from the group consisting of alumina, spinel and steatite.

30. (previously presented) The multilayered air-fuel ratio sensor according to claim 1, wherein said insulating substrate layer is made of alumina.

31. (previously presented) The multilayered air-fuel ratio sensor according to claim 10, wherein said insulating substrate layer is made of alumina.

32. (previously presented) The multilayered air-fuel ratio sensor according to claim 18, wherein said insulating substrate layer is made of alumina.

33. (previously presented) A multilayered air-fuel ratio sensor having a plurality of stacked layers comprising:

a plurality of substrate layers comprising one solid electrolytic substrate layer serving as a ceiling or a bottom of a sample gas chamber into which a sample gas is introduced and another solid electrolytic substrate layer defining side walls of said sample gas chamber; and

a boundary layer interposed immediately between said one solid electrolytic substrate layer and said another solid electrolytic substrate layer without any other intervening layer;

wherein each of said one solid electrolytic substrate layer, said another solid electrolytic substrate layer, and said boundary layer is obtained by sintering original particles of a source material so as to change the original particles to sintered particles, and an average size of the sintered particles of said boundary layer is adjusted to be larger than an average size of the sintered particles of each of said solid electrolytic substrate layers.

34. (previously presented) The multilayered air-fuel ratio sensor in accordance with claim 33, wherein said boundary layer is made of α -alumina with an average sintered particle size of 3 to 4 μm .

35. (previously presented) The multilayered air-fuel ratio sensor in accordance with claim 33, wherein

said solid electrolytic substrate layers are made of partially-stabilized zirconia with an average sintered particle size of 2 to 3 μm , and

said boundary layer is made of α -alumina with an average sintered particle size of 3 to 4 μm .

36. (previously presented) The multilayered air-fuel ratio sensor in accordance with claim 35, wherein

an alumina green sheet for said boundary layer has an average particle diameter smaller than that of a zirconic green sheet for said solid electrolytic substrate layers.

37. (previously presented) The multilayered air-fuel ratio sensor in accordance with claim 33, wherein

said solid electrolytic substrate layers are made of partially-stabilized zirconia and said boundary layer is made of alumina, and

a thermal expansion coefficient of said partially-stabilized zirconia is substantially the same as that of said alumina.

38. (previously presented) The multilayered air-fuel ratio sensor according to claim 33, wherein said boundary layer has a thickness in a range of 10 to 100 μm .

39. (previously presented) A multilayered air-fuel ratio sensor having a plurality of stacked layers comprising:

a plurality of substrate layers comprising one solid electrolytic substrate layer serving as a ceiling or a bottom of a sample gas chamber into which a sample gas is introduced and another solid electrolytic substrate layer defining side walls of said sample gas chamber; and

a boundary layer interposed immediately between said one solid electrolytic substrate layer and said another solid electrolytic substrate layer without any other intervening layer;

a thermal expansion coefficient of said partially-stabilized zirconia is substantially the same as that of said alumina.

44. (previously presented) The multilayered air-fuel ratio sensor according to claim 39, wherein said boundary layer has a thickness in a range of 10 to 100 μm .

45. (previously presented) The multilayered air-fuel ratio sensor according to claim 1, wherein an average size of the original particles of said boundary layer is smaller than an average size of the original particles of each of said substrate layers.

46. (previously presented) The multilayered air-fuel ratio sensor according to claim 18, wherein an average size of the original particles of said boundary layer is smaller than an average size of the original particles of each of said substrate layers.

47. (previously presented) The multilayered air-fuel ratio sensor according to claim 33, wherein an average size of the original particles of said boundary layer is smaller than an average size of the original particles of each of said substrate layers.

48. (previously presented) The multilayered air-fuel ratio sensor according to claim 39, wherein an average size of the original particles of said boundary layer is smaller than an average size of the original particles of each of said substrate layers.

(IX) EVIDENCE APPENDIX

(NONE)

SUGIYAMA et al
Serial No. 09/098,730
Amended Appeal Brief
September 7, 2006

(X) RELATED PROCEEDINGS APPENDIX

A copy of the Decision mailed July 8, 2003 in Appeal No. 2002-1284 is attached hereto.